O MUNDO DA SAÚDE

Physical activity, screen time, and sleep quality of students during remote learning

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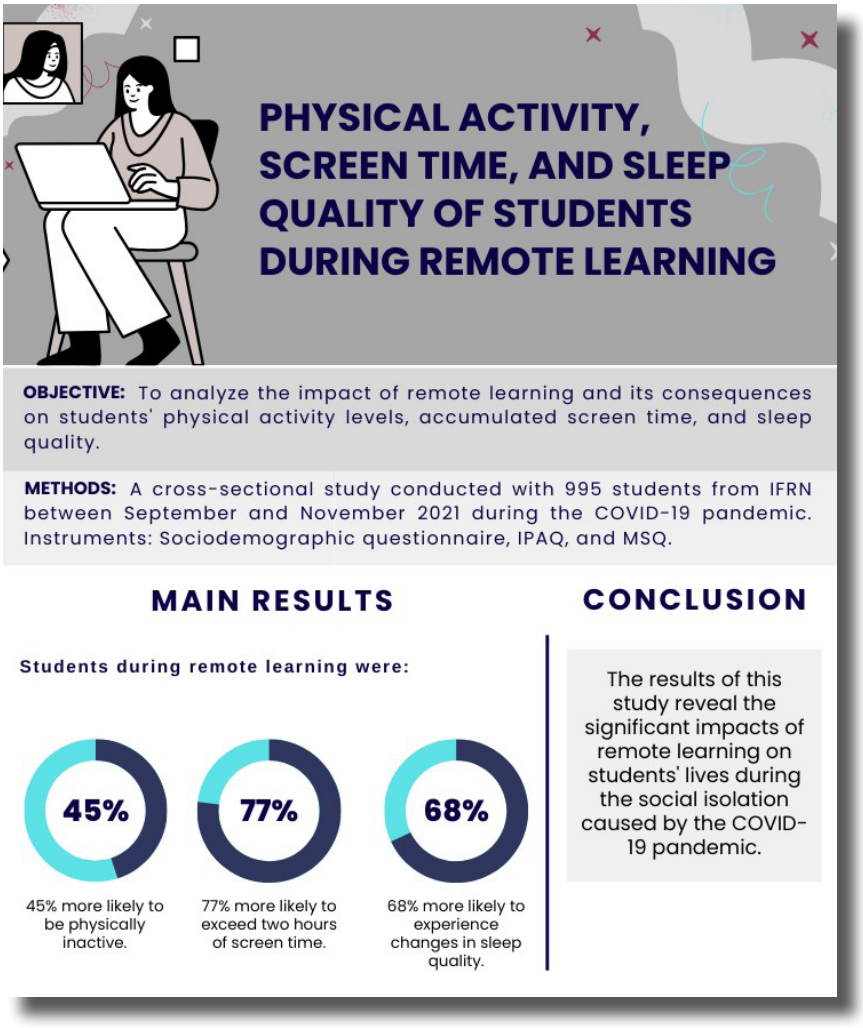
Graphical Abstract



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Abstract

The health and social crisis triggered by the coronavirus disease 2019 (COVID-19) pandemic significantly impacted society as a whole. In the educational context, social isolation and remote learning may have exacerbated unhealthy behaviors among high school students, such as excessive screen time and poor sleep quality. This study aimed to analyze the impact of remote learning and its consequences on students' physical activity levels, accumulated screen time, and sleep quality. A cross-sectional study was conducted with 995 high school students, with a mean age of 22.34 ± 7.46, encompassing all 20 academic units of the Federal Institute of Rio Grande do Norte, Northeast Brazil. Data were collected between September 8 and November 29, 2021. An online questionnaire was structured, including recall information about behaviors before and during remote learning. Validated instruments were used to measure physical activity levels (IPAQ), exposure to recreational screen time, and sleep quality (MSQ). During remote learning, participants were more likely to be physically inactive (OR: 1.45, p-value <0.001), have more than two hours of screen time (OR: 1.77, p-value <0.001), and experience poorer sleep quality (OR: 1.68, p-value <0.001). These behavioral changes reflect the impact of adopting remote learning on students' routines and health, highlighting the importance of social and educational organization with preventive approaches and interventions focused on health behaviors during public health challenges like this.

Keywords: Pandemic. Physical Exercise. Physical Inactivity. Sleep. Sedentary Behavior.

INTRODUCTION

The novel coronavirus emerged in December 2019 in China and was named *"severe acute respiratory syndrome coronavirus-2"* (SARS-CoV-2), with the associated disease termed "coronavirus disease 2019" (COVID-19), which was declared a pandemic on March 11, 2020[1]. In the absence of effective treatments, the World Health Organization (WHO) recommended preventive measures, such as frequent hand hygiene, mask use, and social distancing, which were fundamental strategies to curb the exponential increase in cases and prevent overburdening health services[1]. Social distancing encompassed various measures to reduce the movement of people in public or private collective spaces, including changes in the educational modality[2].

In this context, since the beginning of the pandemic, significant attention has been given to understanding the psychological effects of transitioning to remote learning, particularly among university and postgraduate students[3]. Studies have documented a wide range of concerns and anxieties faced by students worldwide, including worries about personal health, social stigma, prejudice, and discrimination. For instance, research revealed that nearly one in four undergraduate students experienced some form of COVID-19-related anxiety[4,5].

These psychological challenges were exacerbated by the need to adapt to remote learning, where students faced additional difficulties such as a lack of social interaction, increased accumulated screen time, and challenges with time management[4]. Furthermore, it is important to consider that age and gender may play a significant role in this dynamic[1]. These factors can impact sleep quality, as active individuals are more likely to demonstrate better sleep quality compared to those with sedentary behavior or physical inactivity[6].

According to the Brazilian Physical Activity Guidelines for the Brazilian Population[7], individuals aged 5 to 17 should accumulate at least 60 minutes of moderate to vigorous physical activity daily, including activities that strengthen muscles and bones at least three times per week. It is also recommended to limit recreational screen time to a maximum of two hours per day and prioritize 9 to 11 hours of sleep for children and 8 to 10 hours for adolescents, with consistent bedtimes and wake-up times. For adults aged 18 to 64, the guidelines suggest accumulating at least 150 minutes of moderate or 75 minutes of vigorous physical activity weekly, along with incorporating muscle-strengthening exercises two or more times per week. The guidelines also emphasize

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the importance of reducing sedentary behaviors and ensuring 7 to 9 hours of sleep per night with regular sleep schedules.

It becomes evident that, despite the easing of the pandemic, the deterioration of healthy habits and the negative health effects resulting from social isolation warrant detailed investigation[2,8,9]. Previous studies have explored the psychological and social impacts of the pandemic, but there remains a gap in the analysis of lifestyle habits such as physical activity, screen time, and sleep quality, particularly during remote learning[1,3]. Furthermore, there is a lack of specific data on the Brazilian population, highlighting the need for further research. Brazil faced significant challenges during the pandemic. Delays in vaccine distribution impacted the youth, a crucial population for mitigating the pandemic's impact. Additionally, state and municipal decrees varied widely, influencing school closures[10].

Thus, the aim of this study was to analyze the impact of remote learning and its consequences on students' physical activity levels, accumulated screen time, and sleep quality. It was hypothesized that the adoption of remote learning results in a reduction of healthy habits among students.

METHODS

This was a cross-sectional study conducted at a public educational institution. The study sample consisted of students from integrated high school courses, subsequent courses, undergraduate, and postgraduate programs across the 20 campuses of the Federal Institute of Education, Science, and Technology of Rio Grande do Norte (IFRN). Rio Grande do Norte has a Human Development Index (HDI) of 0.684. During this study, Brazil recorded a total of 523,587 deaths from the disease as of July 8, 2021; in Rio Grande do Norte, 8,706 deaths were reported by that date (LAIS, 2023). COVID-19 vaccination in Rio Grande do Norte began in January, but despite a reduction in the number of new cases in the state, three surges were recorded: May 2021, June 2021, and November 2021, with a moving average of 329 new cases.

The eligible population for this study consisted of 20,567 students, distributed among the courses as follows: integrated high school (n=13,252), subsequent courses (n=2,076), and undergraduate and postgraduate programs (n=5,239). Of these, 1,054 students responded to the questionnaire, and 995 were included in the study after meeting the inclusion and exclusion criteria, as described in Figure 1. The sampling process began with an invitation sent to all students via the institutional system, considering that studies based on electronic forms generally have a low response rate.

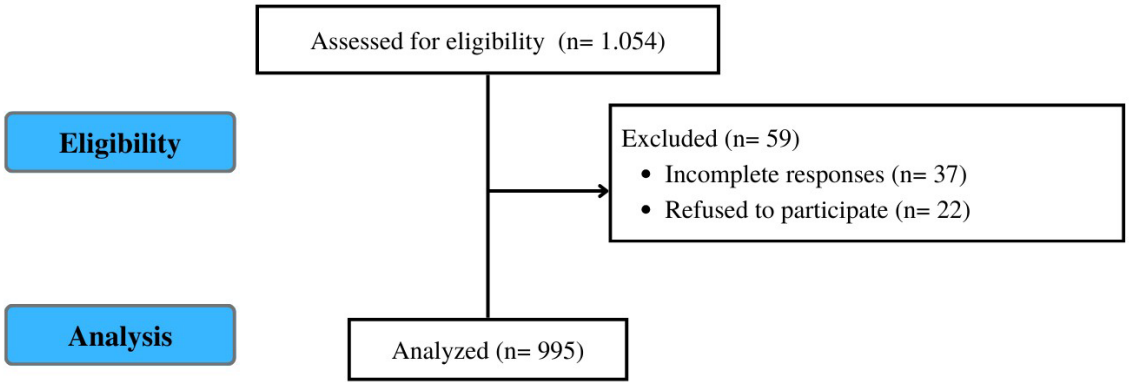

Figure 1 - Flowchart of Research Participant Screening.

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The eligibility criteria for participation in the study included being enrolled in a regular course at the institution, such as integrated technical education, subsequent technical education, technological undergraduate programs, teacher training programs, or postgraduate studies. Individuals who did not fully complete the questionnaire or did not agree to the study's terms were excluded. The research project was approved by the Ethics Committee of the Alberto Santos Dumont Education and Research Institute under protocol number 4.875.581. The principles contained in the Declaration of Helsinki were also followed.

Between September 8 and November 29, 2021, all data collection was conducted electronically through a questionnaire made available on Google Forms®. The questionnaire consisted of four sections. The first section included the Informed Consent Form (ICF) presented to participants of legal age and the legal guardians of underage participants. For the latter, a Free and Informed Assent Form (FIAF) was provided. The second section consisted of questions, developed by the authors, related to sociodemographic aspects, including gender (male and female) and place of residence (metropolitan area or rural area).

The third section was organized based on the recall period: before the pandemic (referring to a period prior to the pandemic, in a context without restrictions or direct impacts) and during the pandemic (referring to the period of questionnaire completion). For this, the short version of the International Physical Activity Questionnaire (IPAQ) was used[11]. Participants were classified regarding their physical activity level into two categories: physically active and physically inactive, according to the Brazilian Physical Activity Guidelines for the Brazilian Population[7].

The average daily screen time was also assessed through a simplified questionnaire previously adopted in population-based studies in Brazil[12,13]. Three questions were asked: "*In a typical week in the last month, how much time did you usually spend...*" 1) "*...watching television, videos (YouTube, Netflix, etc.) or DVDs?*"; 2) "*...on a computer or cellphone (social networks, messaging apps, etc.)*?"; and 3) "*...playing video games?*". The average daily screen time was then calculated by summing the responses to the three questions and dividing the result by 7, as done in the study by Carson *et al.*[11]. Screen time was categorized as up to two hours or more than two hours.

The last section of the Google Forms® questionnaire included the Brazilian version of the Mini Sleep Questionnaire (MSQ), validated in Brazil by Falavigna *et al.*[14]. This section contained 10 multiple-choice questions aimed at assessing sleep quality. Responses were given on a seven-point scale ranging from 1 (never) to 7 (always). The total score was divided into four levels of difficulty sleeping: 10-24 points, good sleep quality; 25-27 points, mild difficulty sleeping; 28-30 points, moderate difficulty sleeping; and ≥31 points, severe difficulty sleeping. Participants' responses were grouped into two main categories: unchanged sleep and altered sleep, the latter being classified when the MSQ score exceeded 28 points.

A post hoc power analysis of the sample was conducted using *OpenEpi* software version 3.01, identifying that the final sample (n = 995) has a statistical power of 98% to detect odds ratios equal to or greater than 1.2 (for physically inactive individuals and screen time exceeding two hours per day) and 1.4 (for altered sleep).

Descriptive data analysis was performed using absolute numbers and percentages. In the inferential analysis, binary logistic regression models were applied to estimate the likelihood of exhibiting negative behaviors during social isolation. Three models were developed, where the dependent variables were physical activity (reference category: physically active), screen time (reference category: less than two hours), and sleep quality (reference category: unchanged). The independent variable was the time variable, with the reference category being the period before social isolation. Control variables included gender, age, race, place of residence, and the presence of risk factors for COVID-19. The models estimated the odds ratios for engaging in negative behavior (physically inactive, more than two hours of screen time, and altered sleep) during social isolation, independent

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of gender, age, race, place of residence, and risk factors. Additionally, interaction analyses between the time variable and gender were conducted, but no significant results were found ($p > 0.05$). Consequently, the analyses were performed with men and women combined.

Predicted proportions of the likelihood of engaging in risky behavior before and during social isolation were also calculated. Predicted proportions were derived using the estimated parameters from the logistic regression model to obtain predicted probabilities for each observation, and then the mean of these probabilities was calculated for each level of the variable of interest (before and during). Statistical analyses were performed using the R statistical software (version 4.4.0, R Core Team, 2024) and corresponding packages ('*ggplot2*', '*lme4*', '*ggeffects*', among others). The coding and execution of the analyses were conducted in the *RStudio* integrated development environment. All analysis scripts are available upon request.

RESULTS

A total of 1,054 students responded to the questionnaire; however, 37 were excluded for incomplete responses, and 22 refused to participate in the study, leaving 995 participants. Table 1 reports the sociodemographic characteristics of the study sample. The majority were female (56.5%, n=562) and aged between 18 and 29 years (44.2%, n=440). Regarding race, most participants identified as non-white (61.2%). A majority resided in rural areas (54.3%) and were enrolled in integrated high school programs (54.6%), while 14.3% were attending subsequent education programs. In terms of COVID-19 risk factors, 23.1% (n=230) belonged to the at-risk group, while 76.8% (n=765) had no associated risk factors.

Table 1 - Sociodemographic characteristics of the sample. Rio Grande do Norte, Brazil, 2021.

Variables	N (995)	%
Sex		
Male	433	43.5
Female	562	56.5
Age		
Under 18	392	39.4
18 to 29	440	44.2
Over 30	163	16.4
Race		
White	386	38.8
Non-white	609	61.2
Place of Residence		
Countryside	540	54.3
Greater Natal	455	45.7
Schooling		
Integrated High School	547	55.0

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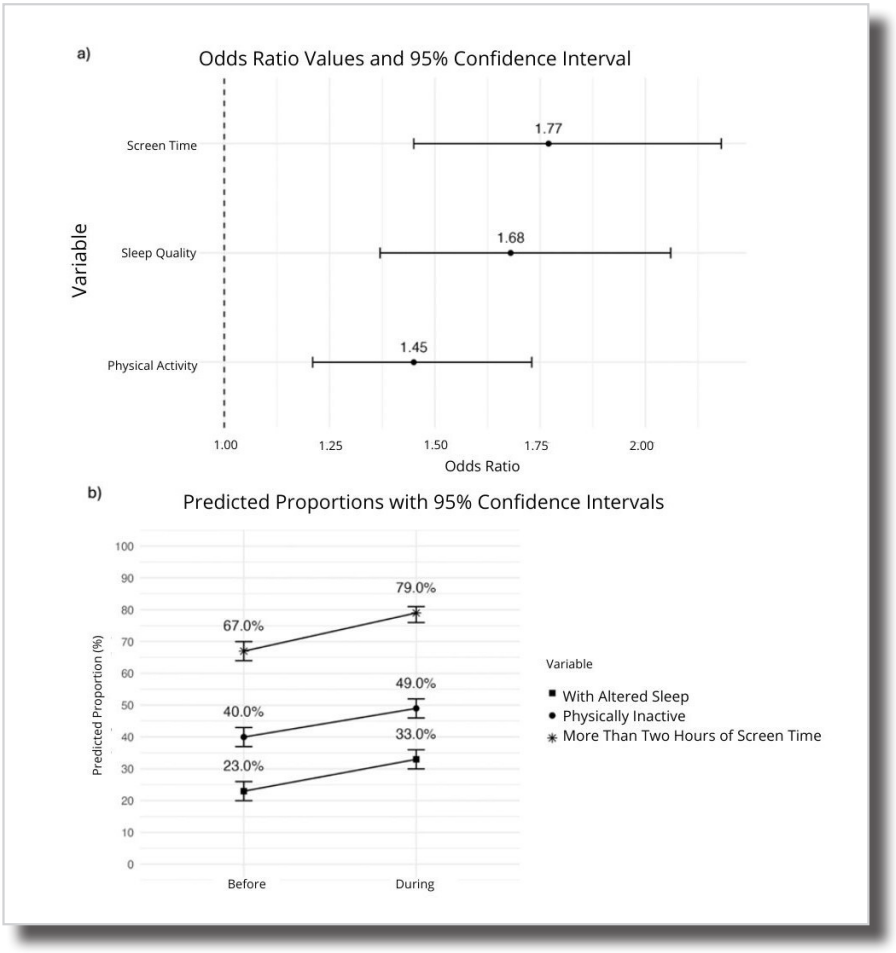
...continuation - Table 1.

Variables	N (995)	%
Subsequent Education	142	14.3
Undergraduate	265	26.6
Postgraduate	41	4.1
Presence of Risk Factors for COVID-19		
At-Risk Group	230	23.1
Non-Risk Group	765	76.8



A) Binary logistic regressions controlled for gender, age, race, place of residence, and presence of risk factors for COVID-19 (p-value < 0.001). Reference categories: physically active, without sleep alterations, and with up to two hours of screen time. B) Predicted proportions were calculated using the estimated parameters from the logistic regression model to obtain the predicted probabilities for each observation, and then the mean of these probabilities was calculated for each level of the variable of interest (before and during).

Figure 2 - Associations in the change of behaviors between before and during social isolation. Rio Grande do Norte, Brazil, 2021.

The regression models demonstrated a significant association between the time variable (before and during) and the three dependent variables: physical activity (OR: 1.45, p-value <0.001), screen time (OR: 1.77, p-value <0.001), and sleep quality (OR: 1.68, p-value <0.001) (Figure 2a). These results indicate that during social isolation, there was a 45% higher likelihood of being physically inactive, a 77% higher likelihood of having more than two hours of screen time, and a 68% higher likelihood of experiencing sleep quality alterations. Consequently, Figure 2b presents the predicted proportions of the probabilities of belonging to the negative behavior groups (physically inactive, sleep alterations, and more than two hours of screen time) before and during social isolation.

DISCUSSION

The present study aimed to analyze the impact of remote learning on physical activity levels, accumulated screen time, and sleep quality among students from the Federal Institute of Education, Science, and Technology of Rio Grande do Norte (IFRN). The results indicated a significant increase in the proportion of physically inactive students, screen time exceeding two hours per day, and worsening sleep quality during remote learning compared to the period before the COVID-19 pandemic.

The reasons for the increase in the proportion of physically inactive students can be attributed to social isolation and the abrupt transition to remote learning, which significantly reduced opportunities for both formal and informal physical activities[15,16]. During the period of in-person learning, students had greater access to organized physical activities, such as physical education classes and extracurricular sports. Existing literature supports our findings; studies conducted in different contexts, such as that by Kopańska *et al.*[17], also observed a reduction in physical activity among adolescents during the pandemic, primarily due to school and sports facility closures as well as mobility restrictions imposed by social isolation.

The increase in screen time among students during remote learning can be explained by the necessity of using electronic devices for academic and recreational activities[18]. With school closures and mobility restrictions, students became more reliant on digital technologies to stay connected, entertained, and informed[19]. This increase in screen time is concerning, as it is associated with several negative health consequences, such as vision problems, physical inactivity, and difficulties concentrating. Previous studies, such as that by Kim *et al.*[20], have shown that excessive screen time is linked to an increased risk of obesity, depression, and sedentary behaviors among adolescents. The rise in sedentary behavior is also associated with shorter sleep duration and poor sleep quality, which are themselves health risk factors[21].

Another issue observed among students relates to sleep problems[22]. It is worth noting that several factors could have contributed to reduced sleep quality during the restrictive period, such as stress, depression, financial concerns, fears, social distancing, uncertainties, changes in teaching modalities, among others[23]. Furthermore, the decline in students' sleep quality may be related to increased screen time and stress associated with changes in daily routines. Excessive use of electronic devices, especially before bedtime, can interfere with melatonin production, a hormone that regulates sleep, leading to difficulties falling asleep and maintaining restorative sleep. Our findings align with studies like that of Cavalcante *et al.*[24], which also reported a deterioration in sleep quality during the pandemic, attributed to increased screen time and psychological stress.

The implications of these results are significant for students' health and well-being. The increase in physical inactivity, screen time, and deterioration in sleep quality can have long-term effects, impairing academic performance and increasing the risk of physical and mental health problems[25,26].

Therefore, it is crucial for educational institutions and policymakers to develop strategies to mitigate these negative impacts. In this context, several countries offer examples of effective policies to address the effects of physical inactivity and sedentary behavior. Canada promotes the 24-Hour Movement Guidelines[27], which integrate recommendations for physical activity, sleep, and sedentary behavior, while Finland implements the Schools on the Move[28] program, encouraging active breaks and active commuting within the

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school environment. In the United Kingdom, the Daily Mile[29] program encourages students to run or walk 1.6 km daily.

Adopting and adapting these strategies in Brazil could be an effective solution, integrating schools, communities, and public policies to promote health and well-being. Interventions such as physical education programs adapted to the home environment, awareness campaigns on the healthy use of digital technologies, and the promotion of good sleep hygiene practices are essential to improve students' health during remote learning periods[30].

This study has some limitations that should be considered. The cross-sectional nature of the study prevents the determination of causality between the variables analyzed. Additionally, the use of online questionnaires may have introduced response biases, especially given the self-assessment of participants' behaviors. Another factor to consider is recall bias, as participants had to remember past information, which could influence the accuracy of their responses. However, the study also has strengths, such as the large representative sample of students from different academic units of the IFRN.

CONCLUSION

The results of this study reveal the significant impacts of remote learning during social isolation on students' lives during the COVID-19 pandemic. A substantial increase in time spent on screens was observed, along with a concerning trend of physical inactivity. Additionally, there was an increase in the proportion of participants reporting changes in sleep quality. In this regard, it is hoped that the issues raised in this study can support the planning and implementation of actions aimed at promoting health and quality of life, with an emphasis on optimizing healthy behaviors in this educational context.

CRediT author statement

Conceptualization: Batista, ES. Methodology: Batista, ES; Bezerra, HX; Maciel, GP; Barbosa Filho, VC; Aniceto, RR. Validation: Batista, ES; Bezerra, HX; Aniceto, RR. Statistical Analysis: Bezerra, HX; Maciel, GP; Barbosa Filho, VC; Aniceto, RR. Formal Analysis: Batista, ES; Aniceto, RR. Investigation: Batista, ES. Resources: Batista, ES. Writing-original draft preparation: Batista, ES; Bezerra, HX; Souza, AA; Castro, MR; Aniceto, RR. Writing-review and editing: Bezerra, HX; Maciel, GP; Souza, AA; Castro, MR; Barbosa Filho, VC; Aniceto, RR. Visualization: Maciel, GP; Souza, AA; Castro, MR; Aniceto, RR. Supervision: Aniceto, RR. Project Administration: Batista, ES.

All authors have read and agreed to the published version of the manuscript.

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